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PATENT SPECIFICATION

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DRAWINGS ATTACHED

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Inventors: ALFRED WILLIAM CROOK and GEORGE JENSON

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Int. Cl.:—F 01 d

COMPLETE SPECIFICATION

Improvements in or relating to Rotor Discs of Axial-Flow Turbo-Machines

We, ASSOCIATED ELECTRICAL INDUSTRIES LIMITED, a British Company having its registered office at 33 Grosvenor Place, London, S.W.1, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to improvements in rotor discs of axial-flow turbo-machines and more particularly to improved lacing means for interconnecting the blades in a disc of such a rotor. The term "turbo-machines" is used in this specification to include turbines and like machines.

The moving blades of the later low pressure stages of large steam turbines, such as are used for driving electrical generators are commonly laced in packets, the lacing means comprising segments of wire extending through holes in the blades and arranged to lie on circles concentric with the rotor axis. The lacing segments can simply extend through clearance holes, or they can be brazed to the blades at the holes, in accordance with the effect desired. The purpose of the lacing means is to change the frequencies of vibration of the blades away from possible frequencies of excitation so that resonant vibrations do not occur. Vibrations of sufficient severity of whatever origin can break the blades and/or the disc through metal fatigue.

In some cases it is possible so to design the blades and disc that without lacing their natural frequencies of vibration are away from probable exciting frequencies. At the low pressure end of the turbine, free blades without lacing form the preferred construction, as lacing forms an impediment to fluid flow. But, particularly with the large turbines now being built and designed, in turbines for the same rotational speed blades longer than used hitherto are employed and these in conjunction with the supersonic velocities which obtain give rise to an enhanced danger of self-excited vibration or flutter. It is prudent, in the present state of the art, to provide means inhibiting flutter even with an advantageous disposition of natural frequencies in relation to the exciting frequencies. To avoid the complications well known in the art arising from packeting, it is desirable that the lacing means should affect all blades equally. Further, it is desirable that the application of the lacing means should be more convenient than the application of segmented lacing means.

An object of the present invention is the provision of improved lacing means for the blades of a rotor disc of an axial-flow turbo-machine.

According to the invention a rotor disc of an axial-flow turbo-machine includes a circumferential row of rotor blades provided with straight lacing members each of which fits into holes in the working or aero-foil portion of only two adjacent blades and has its longitudinal axis extending both axially and circumferentially relative to the rotor disc.

The lacing members can all be arranged in a single row at a constant or substantially constant distance from the rotor axis, or they can be arranged in two or more rows at different radial distances from the rotor axis.

The lacing members of a row can be arranged with their longitudinal axes extending radially relative to the rotor disc so that the lacing members of the row lie around the rotor axis in a conical fashion and form segments of the straight generators of a hyperboloid of revolution about the rotor axis.

It is not essential that both ends of the lacing members should be rigidly connected to the associated blades. Thus one or both ends of a lacing member may be threaded through clearance holes in the blades, suitable means being provided to inhibit undesirable longitudinal movement of the member.

The invention will now be described by way

of example, with reference to the drawings filed with the Provisional Specification and the accompanying drawing, in which:—

Figure 1 is an axial elevation of a rotor disc of a steam turbine rotor;

Figure 2 is a radial view, partly in section, of a small part of the circumference of the bladed disc shown in Figure 1 and shows one way of fitting lacing members to the rotor blades;

Figures 3, 4 and 7 are radial views similar to Figure 2, but showing alternative ways of fitting lacing members to the rotor blades;

Figure 5 is an end elevation of a small part of the circumference of a bladed disc as illustrated in Figure 1 and with the lacing members arranged in a single circular row; and

Figure 6 is an end elevation similar to Figure 5, but with the lacing members arranged on two circular rows.

Referring first to Figures 1 and 2, the rotor disc 1 includes a circular series of rotor blades 2, each blade being formed with two apertures 3 and 4 into which are fitted respectively ends of the lacing members 5. Each lacing member 5 is a tube which extends between the aperture 3 in one blade and the aperture 4 in an adjacent blade so that its longitudinal axis extends both axially and circumferentially relative to the rotor disc 1. Each lacing member 5 is a clearance fit in the associated aperture 3, but axial movement of the member is restrained by a cotter pin 6 inserted into a hole passing through the blade and the member 5 transversely of the aperture 4. The pin 6 also serves to secure in the end of the member 5 a plug 7 which in use prevents leakage of steam through the member 5.

In the use of the turbine disc, either friction will prevent relative movement of the member and the blade, or damping of certain vibrational modes in a turbine blade is effected frictionally between the member 5 and the periphery of the aperture 3.

In the alternative arrangement shown in Figure 3, both ends of a lacing member 5 are clearance fits in their associated apertures 3 and 4, the lacing member being retained in position by engagement of flared ends of the lacing member with the blades. Thus the outer ends of the two apertures 3 and 4 are enlarged and the ends of the lacing member are flared after it has been threaded through the apertures.

In a modification of this arrangement, rotation of the lacing member in the apertures is more positively prevented by a pin, similar to pin 6, threaded through an oblique drilling passing through the flared end of the lacing member and the blade.

In the alternative embodiment shown in Figure 4, one end of the lacing member 5 is a clearance fit in the aperture 3 in a first blade, and the other is connected to the second blade by engagement of a flared end of the lacing member with the second blade, a collar 8 brazed on to the member 5 between the two blades engaging the second blade.

In the alternative arrangement shown in Figure 7 one end of the lacing member 5 is a clearance fit in the aperture 4 in a first blade, and the other end is connected to the second blade by engagement of a crimped portion 5A with the second blade, a plug 7 secured in the end of the lacing member by a pin 9 engaging the second blade. The plug 7 is secured in the end of the lacing member 5 by the pin 9 before the lacing member is threaded through the apertures, and the lacing member is crimped after it has been threaded through the apertures.

All the lacing members 5 in each of the embodiments described above are disposed at a constant or substantially constant radial distance from the rotor axis, as indicated in Figure 5. Alternatively, as indicated in Figure 6, alternate lacing members 5 may be arranged in an outer row and the remaining lacing member arranged in an inner row, the two rows being at different radial distances from the rotor axis. This latter arrangement gives the advantage that each blade has its apertures 3 and 4 at different sections of the blade, thus reducing centrifugal and bending stresses at the blade sections concerned. This latter arrangement also gives an additional choice of position for suppressing vibration of the blades.

It is to be preferred that in all the embodiments of the invention described above an odd number of blades per circle should be used. With an even number of blades it is kinematically possible for alternate blades to twist torsionally in opposite senses without causing sliding of any lacing means in the apertures. With an odd number of blades this is not so.

In the embodiments of the invention described above, the lacing members 5 are in the form of tubes, but in instances where the centrifugal stresses involved permit, solid rods may be used. The material used for the lacing members can be high tensile stainless steel tube or rod. An alternative material is titanium.

WHAT WE CLAIM IS:—

1. A rotor disc of an axial-flow turbomachine including a circumferential row of rotor blades provided with straight lacing members each of which fits into holes in the working or aero-foil portion of only two adjacent blades and has its longitudinal axis extending both axially and circumferentially relative to the rotor disc.

2. A rotor disc as claimed in Claim 1, wherein the lacing members are all arranged in a single row at a constant or substantially constant radial distance from the rotor axis.

3. A rotor disc as claimed in Claim 1, wherein the lacing members are arranged in two or more rows at different radial distances from the rotor axis.

4. A rotor disc as claimed in Claim 2 or Claim 3, wherein the lacing members of a row are arranged with their longitudinal axes extending radially relative to the rotor disc so that the lacing members of the row lie around the rotor axis in a conical fashion and form segments of the straight generators of a hyperboloid of revolution about the rotor axis.

5. A rotor disc as claimed in any preceding claim, wherein one end of a lacing member is rigidly connected to an associated blade the other end being threaded through a clearance hole in the other blade.

6. A rotor disc as claimed in any of Claims 1 to 4, wherein both ends of a lacing member are threaded through clearance holes in the blades and suitable means are provided to inhibit undesirable longitudinal movement of the member.

7. A rotor disc of an axial-flow turbomachine constructed substantially as shown in, and arranged to operate substantially as hereinbefore described with reference to, Figures 1 to 6 of the drawings filed with the Provisional Specification or Figure 7 of the accompanying drawing.

J. W. RIDDING,
Chartered Patent Agent,
33, Grosvenor Place, London, S.W.1.
Agent for the Applicants.

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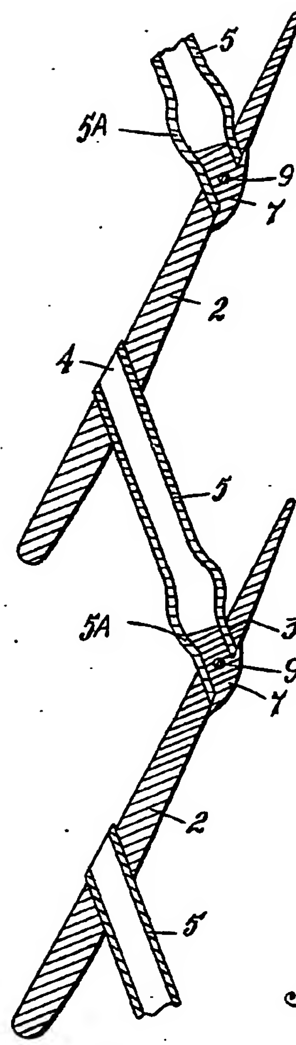

Fig.7.

1037951 PROVISIONAL SPECIFICATION

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Sheet 1

Fig. 1.

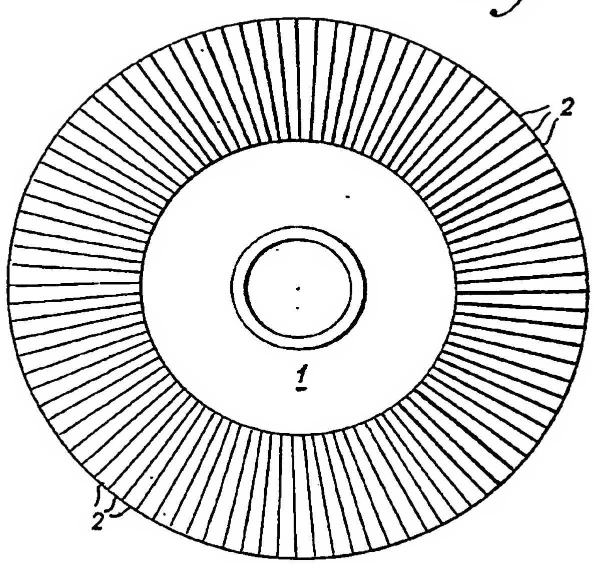


Fig.2.

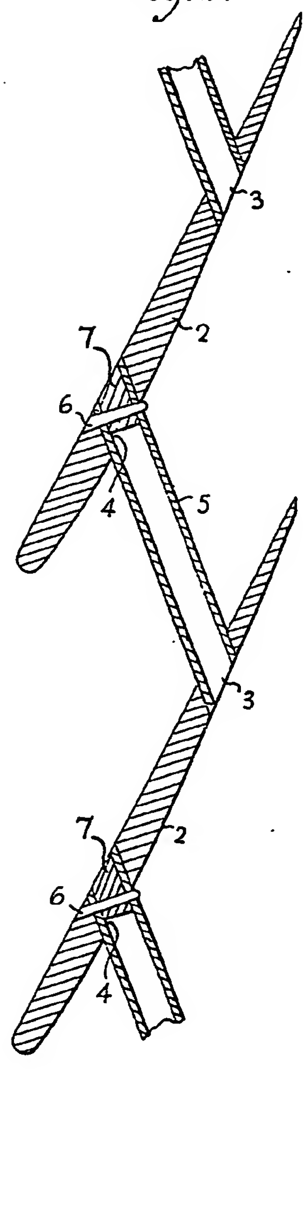
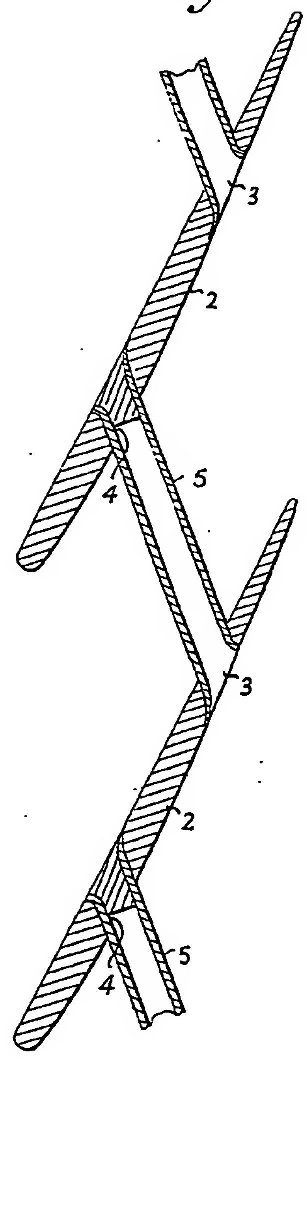


Fig.3.



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.3.

Fig.4.

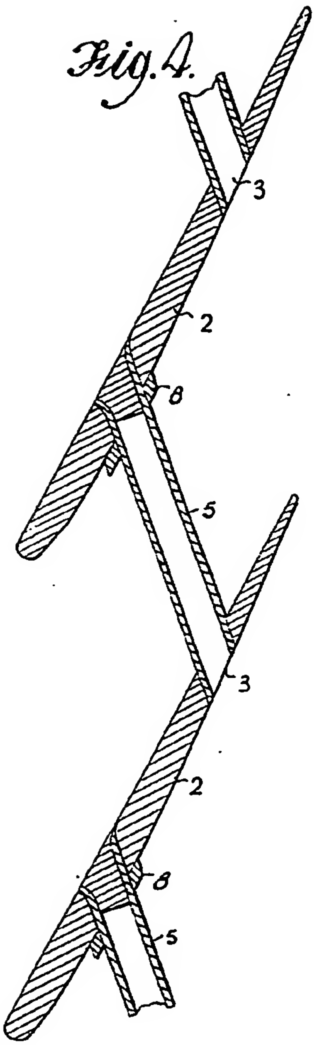

Fig.6.

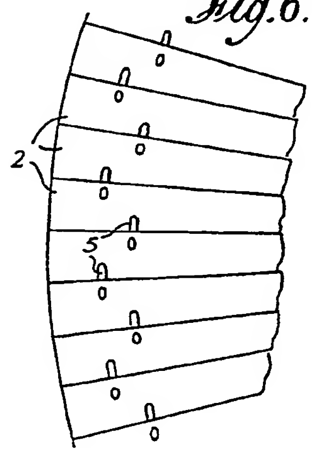

Fig.5.

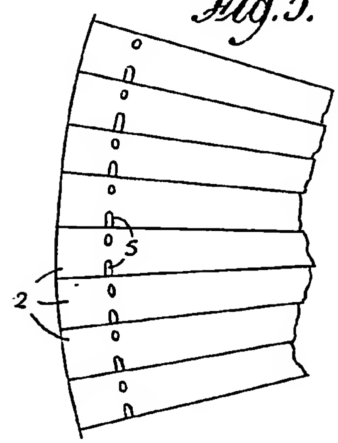

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Fig.2.

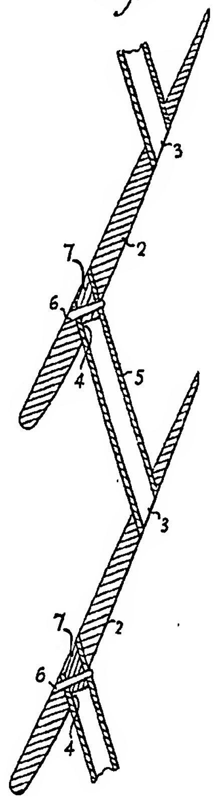

Fig.3.

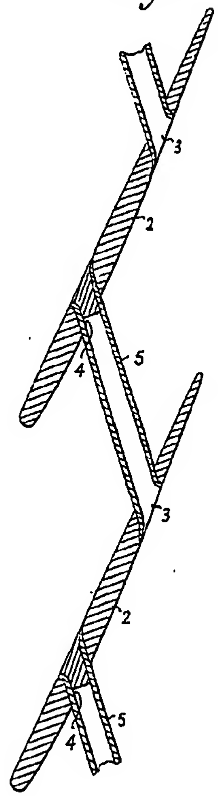

Fig.4.

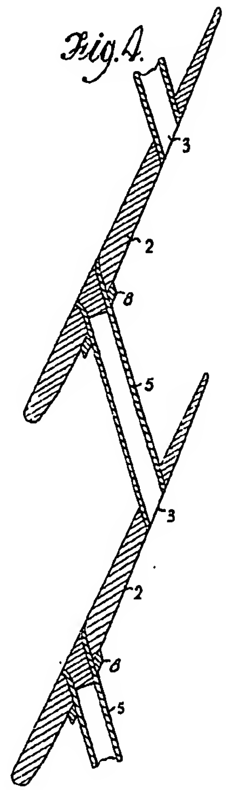

Fig.6.

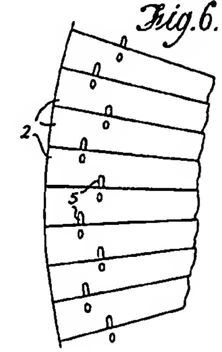

Fig.5.